

SEASONAL VARIATION IN ACTIVITY PATTERNS OF JUVENILE LILAC-CROWNED PARROTS IN TROPICAL DRY FOREST

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ABSTRACT.—We used radio-telemetry techniques to determine hourly activity patterns of 29 juvenile Lilac-crowned Parrots (*Amazona finschi*) during 1996–2000 in tropical dry forest of Jalisco, Mexico. Parrots had two peak activity periods—early morning and late afternoon—for both overall activity and local movement. Individuals were generally inactive and did not change location for 5–6 hr during the middle of the day. Parrots were more active in the dry season than in the rainy season, although movements resulting in a change of location did not vary between seasons. Seasonal variations in activity of Lilac-crowned Parrots may be related to variations in food availability or temperature. Activity patterns of parrots need to be considered when evaluating habitat use or survey data. Received 1 October 2004, accepted 26 April 2005.

When evaluating habitat use, the time of day and the activity being performed by an animal need to be considered, because animals select particular habitats for specific types of activity (Palomares and Delibes 1992). Often, however, studies of habitat use do not take into account activity or inactivity of the individual (Palomares and Delibes 1992).

Daily activity patterns of psittacines have been estimated indirectly from survey data on the frequency of flock encounters, with greater flock activity occurring in the early morning and late afternoon (Snyder et al. 1987, Gilardi and Munn 1998, Wirminghaus et al. 2001), although smaller parrot species may be active throughout the day (Pizo et al. 1997, Gilardi and Munn 1998). Survey data offer an approximation of activity patterns for a species at the population level, but may be limited by the varying detectability of individuals at certain times of the day, or biased toward above-canopy flight characteristics of large flocks. Direct techniques, such as radio-telemetry, offer the opportunity to follow an individual and track its behavior throughout the day, but these techniques have been used infrequently for parrots (Lindsey et al. 1991).

The Lilac-crowned Parrot (*Amazona finschi*) is a threatened species (Diario Oficial de

la Federación 2002) endemic to the Pacific slope of Mexico (Forshaw 1989). Observations of nesting Lilac-crowned Parrots demonstrate that breeding pairs make only two foraging visits to the nest per day: in the early morning and late afternoon (Renton and Salinas-Melgoza 1999). The Red-crowned Parrot (*Amazona viridigenalis*) in northeastern Mexico also makes only two foraging trips to the nest per day (Enkerlin-Hoefflich and Hogan 1997). It is unknown, however, whether these visits reflect general activity periods for parrots, or are specific to nesting pairs. We used radio-telemetry techniques to determine hourly activity patterns of individual Lilac-crowned Parrots in tropical dry forest during both the dry and the rainy seasons.

METHODS

We conducted our study from 1996 to 2000 in the tropical dry forest of the 13,142-ha Reserva de la Biósfera de Chamela-Cuixmala (19° 22' N, 104° 56' W to 19° 35' N, 105° 03' W), Jalisco, on the Pacific coast of Mexico. The topography of the reserve is hilly, and is dominated by tropical dry deciduous forest with semi-deciduous forest in the larger drainages and more humid valleys (Lott 1993). Mean annual precipitation at the study site is 748 mm, with 85% of rainfall occurring from June to October; there is a prolonged drought from mid-February to late May (Bullock 1986). During 1996–2000, mean monthly temperatures were $23.6 \pm 0.27^\circ\text{C}$ (SE) in the dry season (January–May), and $26.9 \pm 0.33^\circ\text{C}$ in the rainy season (July–November).

We fitted radio-transmitters (model SI-2C; Holohil Systems, Carp, Ontario, Canada) onto

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Lilac-crowned Parrot chicks 10 days before fledging, permitting individuals to become accustomed to transmitter collars. Each radio-transmitter was encased in a brass cylinder with a 113-kg-test whip antenna, and crimped, copper tube attachments for the collar (Meyers 1996). Radio-collars weighed 11 g, corresponding to 3% of body weight (Kenward 1987, Renton 2002). Transmitter pulse rate was set at 0.6 p/sec, with a battery life of 12 months. We used TRX-1000S receivers (Wildlife Materials, Inc., Carbondale, Illinois), and located radio-collared parrots by triangulation of simultaneous readings from two of three, fixed telemetry stations (Nam and Boutin 1991). Each telemetry station was fitted with two 11-element, H-type antennas and a null-peak system (AVM, Inc., Isanti, Minnesota), providing a signal detection range of 10–15 km, with an error estimate of 1.4 degrees.

Over the 5 years of study, we obtained activity data on 29 juvenile parrots ($n = 7, 4, 3, 12,$ and 3 parrots in 1996, 1997, 1998, 1999, and 2000, respectively). Activity readings of parrots were not determined until 1–2 months after fledging—once juveniles began moving with adult flocks and their behavior reflected that of adult birds (Salinas-Melgoza 2003). Telemetry sessions were conducted during both the rainy (July–November) and dry (January–May) seasons. Few telemetry sessions were conducted in December, and few successful telemetry sessions could be conducted in June due to seasonal migration of parrots out of the study site (Renton and Salinas-Melgoza 2002). Activity patterns were determined by conducting 13-hr telemetry sessions from the fixed stations, by recording the activity of individuals per hour after sunrise (approximately 06:30–19:30 [CST] in the dry season and 07:30–20:30 in the rainy season). Consecutive readings were taken in each hourly period to determine whether individuals changed location within the hour. Loss of signal with transmitter age and dispersal movements of parrots frequently made detection of individuals difficult; thus, not all telemetry sessions produced activity readings.

Transmitters did not have an activity sensor; therefore, the activity status of each individual was determined by maintaining the antenna in the peak signal direction and registering the level of signal intensity. An indi-

vidual was recorded as active when we registered fluctuations in signal intensity of >0.05 dc milliamperes variation, caused by the individual changing position. We defined two activity categories: (1) rest: individuals with constant, unvarying signal intensity and no change in location or direction angle; and (2) active: individuals with a fluctuating signal intensity, or which changed location or signal direction. We recorded the number of individuals at rest or active during each hourly period, with the sum of the two categories being the total number of individuals recorded for that hour. To evaluate local movements involving flight, a subset of those individuals from the active category that registered a change in location or signal direction, was also defined as moving. Activity patterns were determined as the proportion of individuals per hour registered as active, as well as the subset of individuals in the active category that changed location and may be considered moving.

We used the Kolmogorov-Smirnov test of normality with Lilliefors significance correction (Zar 1999) to determine whether the data deviated significantly from the normal distribution required for parametric analysis. The proportions of individuals registered as active per hour in the dry and rainy seasons were arcsine transformed (Zar 1999) and presented a normal distribution ($K-S_{26} = 0.13, P = 0.20$). We used a paired t -test to compare activity by hour after sunrise between the dry and rainy seasons. Arcsine-transformed proportions for the subset of individuals that changed locations were not normally distributed; therefore, the nonparametric Wilcoxon paired-sample test was used to compare movement between seasons, by hour after sunrise. Data are presented as means \pm SE; significance level was set at $P < 0.05$.

RESULTS

Parrot activity was recorded for 845 hr of telemetry sessions, with 573 hr during the rainy season (July–November) and 272 hr in the dry season (January–May). Not all individuals could be recorded in all telemetry sessions, but we obtained 2,292 activity readings of individual juvenile parrots. Fewer telemetry sessions and activity readings were obtained during the dry season (505 readings) than in

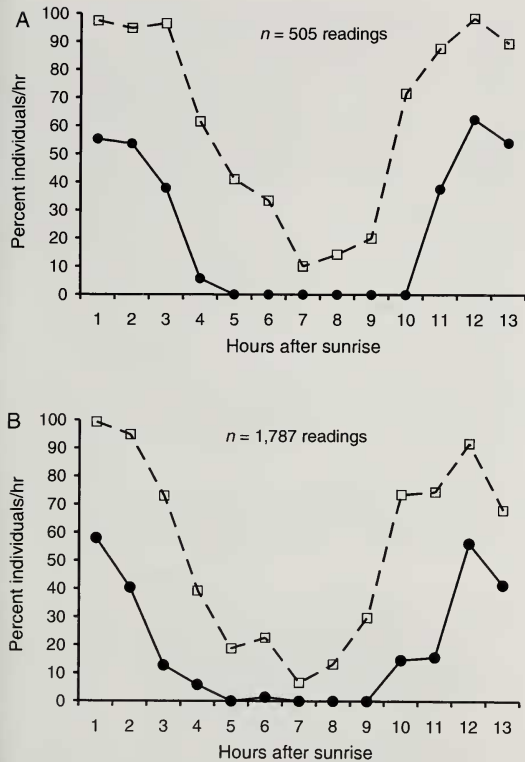


FIG 1. Percent of individual Lilac-crowned Parrots active (dashed line) and changing location (continuous line) per hour after sunrise in (A) the dry season and (B) the rainy season in the Reserva de la Biósfera de Chamela-Cuixmala, Jalisco, Mexico, 1996–2000.

the rainy season (1,787 readings), due to signal loss as transmitters aged and the broad dispersal of parrots during the dry season (Salinas-Melgoza 2003), which made detection difficult. Individuals were followed for 271 ± 27.6 days (range = 55–552, $n = 29$) until the battery died or the signal was lost. Most activity readings were of first-year juvenile parrots; only six individuals were followed >1 year, providing 117 readings that correspond to subadults 13–18 months of age.

Activity patterns of Lilac-crowned Parrots showed two peaks—both for overall activity and when changing location (Fig. 1). Peak activity of individuals occurred in the first 3–4 hr after sunrise and last 4 hr before sunset (Fig. 1), corresponding to the approximate time periods of 06:30–10:30 and 15:30–19:30 in the dry season, and 07:30–10:30 and 16:30–20:30 in the rainy season. Local movements of individuals changing location occurred in

the first 3 hr after sunrise and last 2 hr before sunset (Fig. 1), approximately 06:30 to 09:30 and 17:30 to 19:30 in the dry season, and 07:30 to 10:30 and 18:30 to 20:30 in the rainy season. During a large part of the day (11:00–16:00), parrots demonstrated low levels of activity and did not change location (Fig. 1). Peak periods in the early morning and late afternoon for active and moving individuals were similar in both the dry and rainy seasons. However, the percent of individuals active in the dry season (all-day mean = $62.7\% \pm 9.57$) was greater than in the rainy season (all-day mean = $54.2\% \pm 9.28$), with significant variation between seasons in the proportion of individuals active per hour of the day (paired $t_{12} = 2.7$, $P < 0.019$; Fig. 1). By comparison, the percent of individuals that changed location per hour of the day did not vary significantly between seasons (all-day mean for dry season = $23.5\% \pm 7.33$, rainy season = $18.9\% \pm 6.12$; $Z_{13} = 1.13$, $P = 0.26$).

DISCUSSION

Individual Lilac-crowned Parrots had two periods of peak activity—during the first 4 hr of the morning and the last 3 hr of the afternoon—when parrots are most likely to be foraging (Snyder et al. 1987). Peak movements of individuals in the early morning and late afternoon corresponded with the behavior of parrot flocks traveling between communal roost sites and foraging areas (Renton and Salinas-Melgoza 2002). Peak periods of activity and movements of individuals in the early morning and late afternoon make these the times of day when parrots are most likely to be detected during surveys, and correspond with the activity patterns estimated from survey data (Snyder et al. 1987, Gilardi and Munn 1998). Moreover, the same activity periods were observed for nesting parrots (Enkerlin-Hoeflich and Hogan 1997, Renton and Salinas-Melgoza 1999) and may reflect a general activity pattern irrespective of the age group or reproductive status of individuals.

Because Lilac-crowned Parrots are inactive for 5–6 hr of the day, periods of rest or activity by parrots need to be considered when using radio-telemetry data to evaluate habitat use. Habitat selected for resting likely differs from that for foraging because cover and security are more important when resting.

whereas food availability is more important when foraging (Palomares and Delibes 1992). Failure to take activity into account creates bias in estimates of habitat use, particularly for animals that spend part of the day inactive, because foraging habitat will be underestimated (Palomares and Delibes 1992).

The low activity exhibited by Lilac-crowned Parrots during part of the day may be related to diet, suggesting that parrots are able to meet their nutritional requirements by foraging during a few hours in the morning and afternoon. The Lilac-crowned Parrot is predominantly granivorous and exploits locally abundant seed resources (Renton 2001). Seeds are high in proteins and minerals (Gibaldi 1996) and require longer digestion periods, with consequently greater time between feeding sessions (Karasov 1990, Levey and Martínez del Río 2001). Frugivorous birds, by comparison, have rapid transit times of fruit in the gut, with a consequent increase in consumption rate (Levey and Karasov 1989, Martínez del Río and Restrepo 1993). Hence, granivorous Lilac-crowned Parrots may be able to meet their energetic needs in a few feeding bouts throughout the day.

The seasonal variation in activity levels of Lilac-crowned Parrots may be related to seasonal changes in food resource availability (Renton 2001). Decreased food availability in the dry season (Renton 2001) may require parrots to increase time spent foraging to obtain sufficient food resources. Anecdotal observations of parrots in the Australian wheat-belt suggest that parrots increase time spent foraging when food availability is low (Rowley 1990, Rowley and Chapman 1991). Average monthly temperatures also are greater in the rainy season than in the dry season and may influence parrots to seek cover or conserve energy by decreasing activity during the warmer months. However, we obtained fewer activity records of Lilac-crowned Parrots during the dry season than in the rainy season, because the broad dispersal of parrots during the dry season (Salinas-Melgoza 2003) made individuals more difficult to detect. By comparison, the pattern of changing locations did not vary between seasons, because these movements tend to reflect local flights between roosting and foraging sites—a consistent element of Lilac-crowned Parrot behavior.

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